Partnership to Build a MAG*SEP^{SM} Particle Production Facility

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Introduction

Company Background
Bradtec Ltd. was formed in the United Kingdom in April 1989. In August 1989, Bradtec-US, Inc. (now Selective Environmental Technologies, Inc., "Selentec") was formed as a wholly owned subsidiary of Bradtec, Ltd. Selective Environmental Technologies, Inc. is a Georgia corporation with its principal offices in Atlanta, GA. Selentec has become an important participant in the environmental remediation marketplace through the development of three technologies which focus on treating soil and water contaminated with radionuclides, heavy metals, and nitrates. These technologies (which are protected by patents) have been selected by the US Department of Energy ("DOE") for a series of pilot-scale and full-scale demonstrations which began in late 1994 and are scheduled to continue through 1998.

MAG*SEP^{SM} Technology
One of Selentec's three principal technologies is the MAG*SEP^{SM} process. The process, which earned a 1997 R&D 100 award, selectively removes contaminants from water (or other liquids) using selective adsorption and magnetic filtration. The process treats heavy metals and radionuclides. This is possible through the use of MAG*SEP^{SM} particles, engineered by Selentec, which consist of a magnetic core, a polymer matrix, and an appropriate selective adsorber coating. The primary benefit of this technology is that it recovers the contaminants from water (or as demonstrated for the Ukrainian government, milk) without removing non-hazardous minerals. This allows the potential to recycle the material recovered, or if it must be disposed of as waste, produces minimal waste volumes. This also has the benefit of not significantly altering the treated water chemistry, which is important in returning treated groundwater to the environment.

The process is applied by injecting the MAG*SEP^{SM} particles into the liquid stream that is to be treated. The particles are allowed the appropriate residence time (depending on kinetics specific to the contaminants of concern) in a stirred tank or length of pipe. The stream then passes through any of several commercially available magnetic separators that use the particles' magnetic core to separate them from the process stream. The particles can then be regenerated for reuse, or reused immediately depending on particle capacity and contaminant concentration. The magnetic property of the particles allows the technology to be applied to streams with high suspended solids content and/or at very high flow rates.

The MAG*SEP^{SM} process has been demonstrated at bench and pilot scales for several DOE applications. A 15 gallon per minute pilot scale MAG*SEP^{SM} system at Savannah River Site (SRS) successfully demonstrated selective removal of a heavy metal contaminant (nickel 1000 ppb reduced to < 100 ppb) in the presence of competing ions (50 ppm aluminum, 40 ppm magnesium, and 60 ppm calcium), magnetic recovery of the MAG*SEP^{SM} particles from the groundwater, and regeneration of the particles.[1] Laboratory studies performed by the Savannah River Technology Center indicated that MAG*SEP^{SM} offered the best method for removing mercury (present in cationic, anionic, and metallic forms) from drums containing heavy water, allowing the drums to be more economically processed.[2] Bench scale investigations using MAG*SEP^{SM} particles to selectively recover heavy metals (iron, copper, zinc, aluminum) from Berkeley Pit water indicated the potential for resource recovery from acid mine drainage.[3] Additionally, MAG*SEP^{SM} was one of only 5 treatment technologies (and the only one that recovers metals and radionuclides from water) selected by a joint committee of the Departments of Commerce, Energy, and Defense, and the Environmental Protection Agency for participation in the Rapid Commercialization Initiative.

Another application of the MAG*SEP^{SM} technology is for the removal of radioactive cesium and strontium from Ukrainian milk. The milk contamination is the result of the Chernobyl disaster (the soil is contaminated with cesium and strontium, grass growing in this soil picks up the contamination, cows eat the contaminated grass and produce contaminated milk). Testing has shown that cesium/strontium specific MAG*SEP^{SM} particles remove 90+% of the activity from milk (initial activity ranging from 88 to 2900 Bq/L) without appreciable reduction in nutrients.[4,5] The first full-scale (capable of treating up to 100 gpm) MAG*SEP^{SM} milk treatment system has been installed at a dairy in the contaminated zone of Ukraine. This system will go on line for testing in November, 1997 and be operational in the spring of 1998 when milk production starts again.

Competitive Analysis of the Technology

The primary alternatives to MAG*SEP^{SM} for water treatment include: precipitation, filtration, ion exchange, and reverse osmosis. The difficulty with the existing technologies other than MAG*SEP^{SM} is that they are energy intensive and non-selective.

Precipitation, Filtration, Ion Exchange

With existing technologies, the liquid may require pH adjustment to precipitate the contaminants, then filtration (to remove suspended solids), followed by ion exchange to reduce contaminant levels to acceptance standards. These processes require high energy costs to pump the liquid through the filters and ion exchangers. Additionally, precipitation, filtration, and ion exchange produce large volumes of non-hazardous solids to capture the contaminants, since the processes are not contaminant selective. In many cases the concentration of the contaminant(s) is < 1 ppm, while non-hazardous solids are several hundred ppm. This results in waste volumes that are several hundred times those possible with MAG*SEP℠. Because the waste produced by precipitation, filtration and ion exchange contains hazardous materials, it must be disposed of at special disposal sites, at high cost. MAG*SEP℠ is especially effective in treating large volumes of water which contain small concentrations of contaminants and large concentrations of non-hazardous solids. Under these conditions, the MAG*SEP℠ particles are injected into the water where they selectively adsorb the contaminant(s) of concern, leaving other solids unaffected. For MAG*SEP℠ the treatment costs are estimated at $0.0019 to $0.005 depending on flow rate, contaminant loading, and water chemistry.[6,7] The estimated cost for water treatment by ion exchange only is between $0.003 and $0.018 per gallon.[8] The cost for precipitation/filtration and ion exchange is estimated to be $0.054 per gallon.[9]

<u>Reverse Osmosis</u>

Reverse Osmosis does not produce the large waste volumes that precipitation, filtration, and ion exchange do. However, reverse osmosis is not selective and is not suitable to treat several thousand gallons per minute, which is required in many treatment applications. Also, reverse osmosis requires prefiltration to prevent clogging the membrane, which generates a secondary waste that must be disposed. Reverse osmosis has higher costs than precipitation/filtration/ion exchange, but cost estimates have not been researched.

DOE has estimated that new technologies can save the US DOE $0.05 per gallon of water treated.[10] Although DOE has not attributed this savings directly to Selentec's MAG*SEP℠ technology, their literature and information videos highlight only the MAG*SEP℠ technology for in-situ treatment of metals and radionuclides.[11, 12]

Objective

By 1995, DOE had recognized the potential for the MAG*SEP℠ process to offer a superior solution to many of its environmental problems. However, Selentec was still producing MAG*SEP℠ particles in its laboratory in batches ranging from 1 to 6.5 pounds, depending on particle type. To provide for the expanded testing and evaluation of the MAG*SEP℠ technology by DOE, Selentec had to develop larger scale particle production capabilities. Additionally, for DOE to evaluate the technology for large scale applications, the evaluation would need to be based on the performance of particles produced on a larger scale.

As a small business with a commercially unproven technology, Selentec did not have the financial resources to have a pilot MAG*SEP℠ particle production facility designed and constructed. In September 1995, Selentec and DOE's Office of Science and Technology entered into a cooperative agreement to cost share, on a 50-50 basis, the construction of a pilot facility to produce MAG*SEP℠ particles at a commercial scale. The agreement allows DOE to eventually recover its cost share through royalties paid as a percentage of revenues received from the domestic sale of treatment systems, particles, or license agreements.

Selentec had found that many potential investors are only willing to put money "at risk" when there is only little or no risk. Providing projections of future business without tangible evidence of that business is not sufficient to raise capital. The cooperative agreement was a clear demonstration of the benefit perceived by the US Department of Energy, and its desire to deploy the technology to save costs in clean-up activities. Selentec hoped that this signal from the DOE would assist Selentec in its efforts to raise financing for its portion of the cost share for this project as well as for other capital requirements.

Approach

The project is broken down into two phases. Phase I includes site selection, scale-up testing, and preliminary design. Phase II consists of detailed design, equipment procurement, construction, and start-up. Under the terms of the cooperative agreement, DOE would be responsible for funding of all costs during Phase I. If Phase II is not authorized by DOE upon completion of Phase I, Selentec will have no cost share obligations for Phase I.

Project Description and Results

Site Selection

The initial intent, under the cooperative agreement, was to utilize an existing building in the TNX Area of SRS for the pilot facility, with a 40 year lease for $1 per year. Selentec was to coordinate with the designated SRS site contractor representatives to define the facility requirements and to determine the appropriate facility considering space, access, storage, health & safety, and services requirements. To assure that the placement of the facility at SRS would be cost effective, and therefore the best option for the project, Phase I included the evaluation of alternative sites for the facility. The sites that were reviewed were SRS, the Mound Advanced Technology Center (Mound), ANL, the Hemispherical Center for Environmental Technology (HCET) at Florida International University (FIU), and a site near the University of Florida (Gainesville), which was the location of a NASA particle research facility.

The site selection process began with the development of questionnaires that were used to make preliminary evaluations of the sites to reduce the number under consideration. The questionnaires were distributed to the various sites along with a list of weighted technical and financial criteria that would be used for determining which sites to explore further. Upon review of the responses submitted by the prospective sites, it was determined that SRS and ANL were not viable options, more information was required from Gainesville, and that Mound and HCET at FIU were promising options worthy of further consideration. When the additional information requested from Gainesville was received, it was determined that neither of the two proposed sites in Gainesville was acceptable. The primary reasons that SRS was removed from consideration were that the proposed building would provide inadequate space (more than half of the process area was occupied by equipment for an ion exchange process that could not be removed) and could not be conveniently expanded, and site specific operating restrictions would complicate operations.

Following site visits to Mound and FIU, which confirmed that the facilities available at either site would be adequate, Selentec entered negotiations with both sites. Complications developed with the primary building under consideration at FIU. The building, formerly a research facility for Cordis, had been purchased by the FIU Foundation (an alumni association). The state of Florida was then to buy the building from the Foundation for the University. The FIU Foundation was concerned about the liability of FIU entering into an agreement with Selentec to locate in the building and risk the chance that the state would choose not to buy the building for the University. Because of this situation, FIU reluctantly removed itself from consideration, despite its strategy of developing industry partnerships to strengthen its education resources.

Following detailed negotiations establishing the conditions under which Selentec would locate its particle production facility at Mound, Selentec issued a conditional letter of intent. During meetings held between Miamisburg Mound Community Improvement Corporation (MMCIC), DOE, and Selentec, it became clear that some of the crucial details of the site hand-over from DOE to the city of Miamisburg would not be worked out in a timely fashion. Selentec's primary concerns that could not be satisfactorily addressed were indemnification against business interruption and/or issues relating to site contamination and clean-up caused by past or future DOE or MMCIC actions. Locating at a site under these conditions could be a viable option for an operation that was very labor intensive or which used primarily DOE surplus equipment (i.e., required little or no capital investment), but Selentec would be putting substantial capital investment ($2 million in equipment alone) at risk which was viewed as unacceptable.

Following the inability to reach an agreement with Mound, the site selection process was reopened. FIU indicated that they had resolved their difficulties and were again interested in having Selentec locate its MAG*SEP^{SM} particle production facility there. Similarly, the Southeastern Environmental Resources Alliance (SERA) requested that Selentec again consider locating at Savannah River Site in facilities no longer needed to meet DOE's mission. Additionally, with approval from DOE OTD, Selentec decided to consider commercial sites in the Atlanta and Miamisburg areas.

A second visit to HCET at FIU revealed that there were still issues to be resolved before FIU would be ready for members of industry to locate on site. A representative of SERA showed Selentec personnel several buildings that would be available at SRS. Unfortunately, in addition to Selentec having the same liability concerns as with locating at Mound, the most appropriate building that Selentec was shown required significant modifications.

Selentec obtained approval for a tax exempt industrial revenue bond from Fulton County. Such a bond could have been used to help finance the locating of the particle production facility in an existing building or on a greenfield site in Fulton County which is in the Atlanta area. Selentec suspended further efforts to secure a location in the Atlanta area pending results in Ohio.

The city of Miamisburg aggressively pursued the possibility of Selentec locating the MAG*SEP^{SM} particle production facility there. The commercial realtor who was showing Selentec sites in

Miamisburg, found a building in the city of Vandalia (also located in the Dayton area) that could potentially house the particle production facility. This building, located at 1001 Brown School Road in Vandalia, previously housed a pharmaceutical operation. It sits on 3.9 acres which would provide plenty of room for future expansion. The building has 18,900 ft^2 of production area and 5,600 ft^2 of office and support space. After obtaining estimates for cleaning, painting, and code enhancements, Selentec made an offer to purchase the building. Following negotiations, a mutually acceptable agreement to purchase was reached.

All of the appropriate inspections (including Phase I environmental site assessment and Phase II environmental site investigation) were conducted. The roofing inspection revealed a deflection in one area that caused pooling. The seller agreed to split the estimated cost to repair the roof with Selentec. No other problems were revealed through these inspections. Selentec has purchased the building to house the MAG*SEP^{SM} particle production operations. The city of Vandalia approved a ten year tax abatement of real property taxes for Selentec.

Scale-up Testing

As is the case with most technologies, scaling-up the production of MAG*SEP^{SM} particles from a laboratory scale towards commercial quantities has required significant engineering and testing. Most of this scale-up testing has been conducted at Selentec's Atlanta facility.

The production of Special Magnetic Cores (SMC) has been successfully scaled-up from 900 g/batch with laboratory equipment to 17 kg/batch using pilot scale industrial equipment. The expected production rate for the production facility will be 122 kg/batch (270 lb/batch). The scale-up of this operation occurred in two steps with the intermediate step providing 3.4 kg/batch.

The process that once required a hot plate, a 1 gallon pot, a lab mixer, a 5 gallon wash bucket, and a laboratory buchner funnel, now is performed using a 55 gallon reaction vessel with a heating jacket and a 1.5 hp Lightnin mixer, a 150 gallon wash tank, two 24" table top buchner funnels, and a sealed room with two dehumidifiers. The primary limitation on any further scale-up at the Atlanta facility is the horse power of the mixer motor, because the viscosity of the mixture is very high.

One method of producing MAG*SEP^{SM} particles involves acrylic block polymerization. This polymerization is highly exothermic, which limits the direct scale-up of laboratory methods beyond about 2.4 kg/batch. These 2.4 kg blocks must then be broken and ground to the desired size range. Two alternatives have been identified for scaling-up acrylic block production. They are reactive extrusion and suspension polymerization.

Reactive extrusion is the most direct method of scaling-up the acrylic block method. This process provides several advantages over current laboratory block production. It uses essentially the same mixture of reactants, but, because only a small volume of the reactants are polymerized at any one time, the amount of heat generated at any given time is minimized. The extruder provides efficient heat removal which will allow for the temperature to be maintained at the optimal 70^{o}C.

The temperature control eliminates the need for a catalyst. It offers quasi-continuous operation. The product is discharged in small particles minimizing or eliminating the need for grinding (and the associated loss of fines). The primary drawback to this method of acrylic MAG*SEP^{SM} production is the high capital cost of the extruder itself.

Selentec fashioned a make-shift extruder out of a K-Tron twin-screw volumetric feeder in order to perform some proof of concept testing. The K-Tron was supplied with extended screws (12" longer than the standard model). The bowl that feeds the screws was replaced with a stainless steel block with two penetrations for reactant injection. An electric heating strip was attached to the outside of the screw tubes with a temperature controller.

Several trials were conducted to prove that acrylic MAG*SEP^{SM} particles could be produced using a twin-screw extruder. None of the trials continued for more than about 5 minutes of reaction time, because the solidifying polymer offered more friction than the 0.5 hp motor supplied with the K-Tron could overcome. During the short reaction times, the expected behavior was observed and small quantities of excellent MAG*SEP^{SM} particles were collected. The particles produced by this method ranged in size from 100 to 500 microns (only the largest of which would require grinding). These particles were examined under a microscope which revealed better structural integrity, which is indicative of improved strength over particles made in a single block and then ground.

Suspension polymerization offers another potential scale-up solution to the exothermic acrylic polymerization reaction. With this method, individual beads are polymerized while suspended in a large volume of solvent. The reactors that are used for this process offer efficient heat removal and the solvent provides a large heat sink which allows the optimal temperature of 70^{o}C to be maintained (even more precisely than with the extruder). The temperature control eliminates the need for the catalyst. Once the correct parameters are established, semi-spherical beads would be produced in the desired size range. This would eliminate the need for grinding, tumbling, and sieving. There are two disadvantages to suspension polymerization that have been identified. Typically either the solvent is flammable and requires special handling precautions or the suspension media is water and the reactants are more hazardous than those used with the solvent or the extruder. The second problem is the risk of a runaway reaction if a loss of power allows the reactants to pool at the bottom of the reactor. This requires safety features including back-up power, emergency cooling, and inhibitors that would halt the reaction in an emergency.

Selentec has conducted some suspension polymerization testing with good results. These tests have all been conducted at a 3 liter scale (up to 1 kg of particles). Several different types of particles have been produced by this method. All of the various parameters associated with the reaction contribute to the shape, size, and strength of the product. In particular the speed and shape of the agitator used to provide the desired bead characteristics will vary with different reactor geometries.

Suspension polymerization, under ideal conditions, yields a product that is superior to other methods of production. Unfortunately, the nature of the reactants involved in this method of production would add significant costs and operational complications to the production facility. Selentec intends to continue scale-up testing of suspension polymerization to gain further expertise in this area. The MAG*SEP^{SM} particle production facility will use reactive extrusion to produce acrylic particles of all types with an anticipated production rate of 227 kg/day (500 lb/day). It is hoped that any future MAG*SEP^{SM} particle production facilities (or expansion of the proposed facility) will incorporate suspension polymerization once Selentec has increased its knowledge in this area.

There are several post-polymerization processing steps required to produce MAG*SEP^{SM} particles. These include grinding, tumbling, wet sieving, and wet magnetic separation. These processes have all been scaled-up by at least a factor of 10. Selentec's current grinding equipment produces losses due to fines (< 75 microns) of about 20%. Selentec has successfully demonstrated that, for certain types of particles, about half of these fines can be recycled improving the yield to 90%. This emphasizes the benefit of minimizing the amount of material that must be ground by using reactive extrusion or suspension polymerization.

Scaling-up the production of MAG*SEP^{SM} particles from laboratory sized quantities has resulted in reevaluation of methods used in several steps of the process. Some stages of the laboratory procedure that were possible to do manually required automation as batch sizes increased. Increasing batch sizes also necessitated identification of raw material suppliers that could provide materials in pilot scale to industrial quantities.

Toll processing was explored as an alternative to in house scale-up testing and/or particle production. Visits were made to several toll processing facilities. In each case, the requirements for production of MAG*SEP^{SM} particles were sufficiently unique as to require substantial capital investment by the toll processor. In a specific instance, Selentec sought to have a test of the suspension polymerization process performed by a University pilot polymerization plant, but intellectual property rights could not be guaranteed due to the laws of that state.

In addition to developing knowledge vital to the design of a pilot-scale MAG*SEP^{SM} particle production facility, these scale-up efforts have enabled Selentec to meet its intermediate particle demands from other projects. This would not have been possible using the old laboratory techniques and batch sizes. Selentec's current single shift particle production capacity is approximately 15 kg of MAG*SEP^{SM} particles per day.

Preliminary Design

Selentec invited representatives from five A/E firms to visit Selentec's Atlanta facilities. These interviews provided Selentec an opportunity to begin to evaluate the qualifications of these potential bidders for the design work on this project. They also allowed the bidders to "get to know" Selentec and the key personnel involved in the MAG*SEP^{SM} particle production facility project. During the meetings Selentec familiarized the A/E's with the various methods of producing MAG*SEP^{SM} particles. Selentec also discussed the draft RFP and scope of work with them. Their feedback was incorporated into the final version of the bid package. The bid packages were issued to seven engineering firms. The scope of work outlined in the RFP included developing a preliminary design, completing detailed design, providing permitting assistance, procuring equipment, constructing the facility, providing training, and assistance in start-up. It specified that separate bids be made for developing a preliminary design (including a +/- 10% cost estimate and schedule for all the "Phase II" work) and the Phase II work. Selentec retained the right to re-bid the remaining work after the completion of the preliminary design/cost estimate/schedule.

Selentec received bids from four of the A/E firms. The three best bids all displayed excellent technical competence and had similar financial terms. Industra, Inc. was selected over the other two based on its offer to have its parent company, American Eco, offer assistance in locating financing for this project.

Selentec issued a subcontract to Industra, and preliminary design work commenced immediately. Industra hired GA Tech's Chairman of Polymer Engineering as a consultant for this project.

After several rounds of increasing design detail and design review meetings, Industra submitted its preliminary design package and +/- 10% cost estimate for the MAG*SEP^{SM} particle production facility. A facility constructed according to this design would enable Selentec to produce each of the different types of MAG*SEP^{SM} particles that have been identified to date. It was also expected that the facility would be capable of producing most conceivable future particle formulations. This design would produce 400 to 3,000 lb/day of MAG*SEP^{SM} particles depending on the type and method of production employed.

To enable the multiple types of particles to be produced, the facility would need to accommodate many different hazardous chemicals. Each of these chemicals has different storage and handling requirements which were considered in the design. The design included safety enhancing and labor saving automation. The design also included a well outfitted laboratory, a maintenance shop, and office space.

The estimated cost to construct and start-up such a facility far exceeded the projected budget. Selentec established a goal of reducing the estimated cost. To accomplish this goal it was agreed that a new preliminary design, with fewer capabilities, would be developed.

The proposed reduction in scope included the elimination of silica based MAG*SEP^{SM} particle and phenolic based MAG*SEP^{SM} particle production. The new scope also excludes suspension polymerization as a means for producing acrylic based MAG*SEP^{SM} particles (as discussed in scale-up). This leaves reactive extrusion as the sole method of polymerization for producing acrylic based MAG*SEP^{SM} particles. The new design basis will be for 500 lb/day of acrylic block production through the extruder. These changes in the design will substantially reduce the number and quantity of hazardous materials that will be required for operation. Additionally, most of the equipment that remains from the original design, will be substantially reduced in size due to the lower production rates. In addition to production related changes to the design and cost estimate, it was agreed that the plans for the laboratory and locker room facilities be simplified to reduce costs.

Industra has submitted the revised detailed scope and cost estimate. The estimate to engineer, procure, construct, and start-up the MAG*SEP^{SM} particle production facility as defined by the reduced scope is now close to the original estimate, adjusted for the loss of DOE on-site services and utilities. The design package included a projected schedule for all Phase II related work of 12 months. Industra will present this estimate, along with a proposal for Phase II, to Selentec's key personnel. Following this presentation, Selentec will either request further changes (to reduce the estimated cost) or approve the scope and move to develop a contract for the Phase II work.

ASME Peer Review

In early 1997, several questions were raised within DOE regarding the viability of the MAG*SEP^{SM} process for DOE applications. Continued funding for this and all other DOE MAG*SEP^{SM} projects was being reevaluated. DOE subcontracted the American Society of Mechanical Engineers to conduct an independent review of the MAG*SEP^{SM} technology and its applicability to DOE needs. In April of 1997, a three member panel conducted a three day in depth review of MAG*SEP^{SM}.

The main questions to be answered by this panel were: 1) Is the MAG*SEP^{SM} process scientifically viable for DOE applications? 2) Is there evidence to support the ability of the process to achieve substantial removal of metals and radionuclides from liquids? and 3) Is there evidence that the materials demonstrate sufficient chemical and mechanical stability for applications?

In response to these questions the panel found: 1) "Based on the physical and chemical processes that are involved... the Panel finds that this process is scientifically viable for DOE applications."; 2) "Based on the data provided by SRTC, ANL, and AWE, the Panel concludes that the distribution coefficients for heavy metals and radionuclides are sufficiently high to permit substantial remediation of contaminated liquids."; and 3) "Anecdotal evidence presented by Selentec indicates that there are chemical and mechanical degradation issues. While each individual episode has been addressed and the problem corrected, there is insufficient systematic and comprehensive information available to draw a conclusion regarding the long term mechanical and chemical stability of the particles." Additional findings included: "Based on the available laboratory and field demonstrations to date, this technology shows considerable promise for economical remediation of metals and radionuclide contaminated liquids. It has the potential for successful large scale applications. Additionally, this technology offers the opportunity for resource recovery." And, "The initial economic analysis provided by Selentec shows this technology to compare favorably with others; however, an accurate economic analysis can only be established as a result of full scale field application."

The panel recommended continuation of the development and application of the MAG*SEP^{SM}

technology. Additional recommendations included support for more systematic research into the fundamental behavior of the sorbant materials including kinetics and chemical and physical stability, a systems approach to full scale application of the process, and a thorough economic analysis upon full scale implementation including costs of materials and extent of recycle.

Application

In addition to the various wastewater, groundwater, and surface water applications of direct interest to DOE, the MAG*SEP^{SM} technology can be applied to industrial process and waste streams for contaminant removal and/or resource recovery. A successful full scale demonstration of the MAG*SEP^{SM} process for treatment of contaminated Ukrainian milk may lead to the installation of MAG*SEP^{SM} treatment systems in as many as 30 Ukrainian dairies over the next three years. Other possible applications of MAG*SEP^{SM} in the former Soviet Union include treatment of surface water, groundwater, and baby food contaminated by Chernobyl in Ukraine, Belarus, and Russia. Selentec is also in discussions with several firms in unrelated industries that are interested in MAG*SEP^{SM} for its selective separation capabilities. These applications will require new patent filings and thus cannot be specifically identified in this paper.

Future Activities

Selentec will report to DOE on the results of physical durability and chemical performance tests that will be conducted on a batch of MAG*SEP^{SM} particles produced using its intermediate scale production equipment.

Selentec will be cooperating with potential equipment vendors to test MAG*SEP^{SM} particle production processing techniques on proposed types of equipment. These tests will serve to confirm the applicability of specific types of equipment for Selentec's needs in addition to providing data for proper sizing of equipment. Some of the equipment to be tested include a twin screw extruder, grinding and sieving devices, vacuum belt filters, and magnetic separators.

Following approval of a finalized preliminary design, Selentec will negotiate a new subcontract with Industra for the Phase II work. The Phase II work is anticipated to take 12 months, including employee training and start-up of the particle production facility. Following the successful completion of one batch of MAG*SEP^{SM} particles and Selentec's approval, Industra's scope of work for Phase II will be complete, and Selentec's MAG*SEP^{SM} particle production facility will be considered operational. Selentec will then operate the production facility to produce MAG*SEP^{SM} particles to meet demand.

It is anticipated that DOE will have to perform an evaluation of the project in accordance with the National Environmental Policy Act (NEPA) and give its approval prior to the initiation of construction related activities in Phase II.

Selentec will continue research and development activities in support of the MAG*SEP^{SM}

technology. These efforts will include continued work towards scale-up of the suspension polymerization method of production as well as product and process improvements.

Acknowledgement Information

This project has been active since September 1995. The cooperative agreement was transferred from Savannah River Operations Office to Morgantown Energy Technology Center on September 16, 1996. Mr. William Haslebacher was appointed as Contracting Officer's Representative to the cooperative agreement on January 7, 1997.

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